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Secondary Energy Trading Markets in Community Scale, Description and Implementation

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Abstract

With the energy and environmental problems of human society has become increasingly prominent, distributed energy system (DES) is gained more and more attention and widely used. Community Secondary Energy Trading Markets (CSEM) was established to: 1) deal with the challenge of the sheer variability of local renewable energy; 2) maximizing DES efficiency. In CSEM, we suppose secondary energy is a general manufactured products and it can be traded between different stakeholders. The transaction of secondary energy commodity between different secondary energy consumers and producers based on the trading price, which price is depend on secondary energy production cost and transportation cost. The comparison of CSEM and traditional primary energy markets has been examined. CSEM's mechanism of action and structure also has been introduced. At last, we indicated that urban detailed plan can play a core role to promote the implementation of CSEM.

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Keywords: Community energy system; Low-carbon community; Community energy policy; Secondary energy trading markets; Urban detailed plan

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1. Introduction

In most countries, buildings energy consumption accounts for a substantial part of the energy supplying [1]. In order to settle the problem of energy shortage and environment deterioration, sustainable development which is signified by steady and rapid economic development, higher people's living standards, resources conservation and environmental protection has attracted much attention. To reduce fossil energy consuming by cities have great contributes to sustainable development. As the micro level of low carbon economy, low carbon communities' low energy consumption, low emission and low pollution development have great influence on the implementation of low carbon economy. Therefore, the development of sustainable buildings plays an important role in the transformation of national energy systems into future sustainable energy supplies aiming at reductions in fossil fuel use and CO_2 emissions [2]. Integration of renewable and sustainable energy into existing energy systems must meet the challenge of coordinating fluctuating and intermittent renewable energy production with the rest of the energy system [3,4]. The moderate integration of demand-side energy systems has offers the opportunity to promote overall system efficiency [5]. Execute many demand-side energy systems design and operation as a whole of management is a difficult work: many stakeholders' interest coordination issues and technical obstacles are seeking a proper solution [6]. In order to meet the challenges we had referred, a concept of Community Secondary Energy Trading Markets (CSEM) has been present. We intended to build a community secondary energy commodity (such as electricity, hot water, chilled water) production, transportation and consumption model, relying on the advantage of market-oriented force to promote community energy system efficiency.

2. CSEM and Traditional Primary Energy Market

2.1. Secondary energy commodity market in a community

Primary energy cascade utilization (such as tri-generation systems) and can get the utmost out of local renewable energy resource is the core strengths of distributed energy system (DES). Though tri-generation systems can produce electricity, hot water and chilled water with a certain proportion, a consumer may didn't need three kinds of secondary energy with the certain proportion. The rest of electricity/hot water/chilled water can be sold to neighborhood consumers. At the same time, if a landowner thinks his land price is very high and the rent of all building areas is very expensive. In this case, to build secondary energy producing equipment room is an uneconomic selection compared with to purchase secondary energy from neighborhood proprietors who can produce secondary energy at lower cost. What is important is that a consumer has different secondary energy demand at different times of the day. As shown in Fig.1 and Fig.2, office building and house building have different load static characteristics. Secondary energy commodity trading between different proprietors at a community can be seen as a local community(In this paper, we refer community's geographic meaning, which means a small-scale district with mixed land use, preferably less than 10 km^2, but not limited to such areas) secondary energy trading market (CSEM). In this market, any resident is consumer and producer simultaneously; secondary energy like electricity, hot water and chilled water are seemed as traded commodities. Community municipal pipe network and electricity grid are used for transform hot water or chilled water.

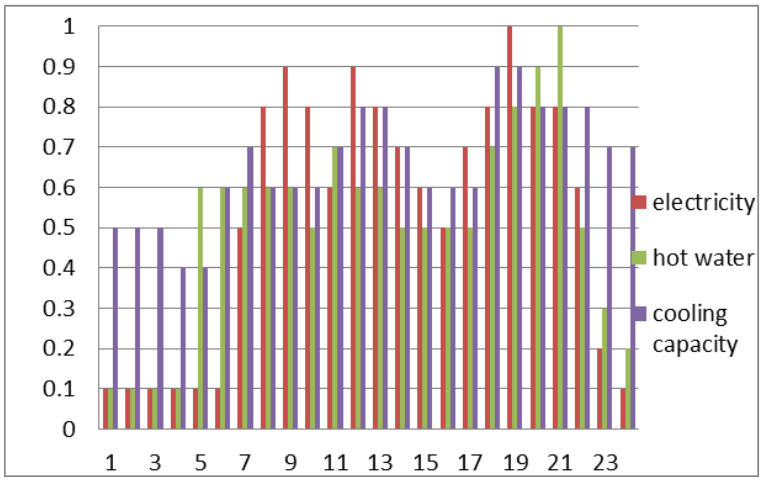

Fig. 1. Load time-varying in a residential building.

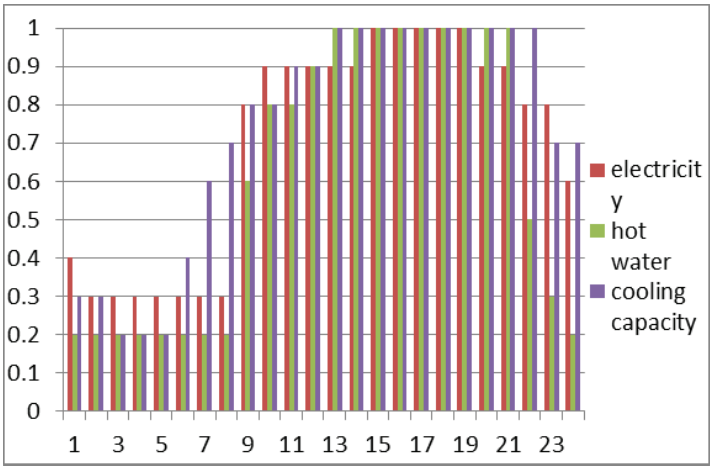

Fig. 2. Load time-varying in a commercial building.

CSEM can be illustrated by Fig.3. In this local secondary energy market, electricity, hot water and chilled water as a commodity being trade off and all demand and supply should be balanced at any time. We suppose secondary energy commodity supplied by different proprietors in various prices. A consumer may be able to produce hot water in a low cost, but when he produces chilled water the cost is expensive. All proprietors tend to purchase secondary energy at an economical cost. So CSEM have the potential to reduce total cost compared with self-sufficient. Secondary energy commodity production, distribution and consumption in a small-scale district (like a community) constitute a CSEM. In most situations, secondary energy storage facilities always use to improve the system's stability and reduce capacity of secondary energy producing devices.

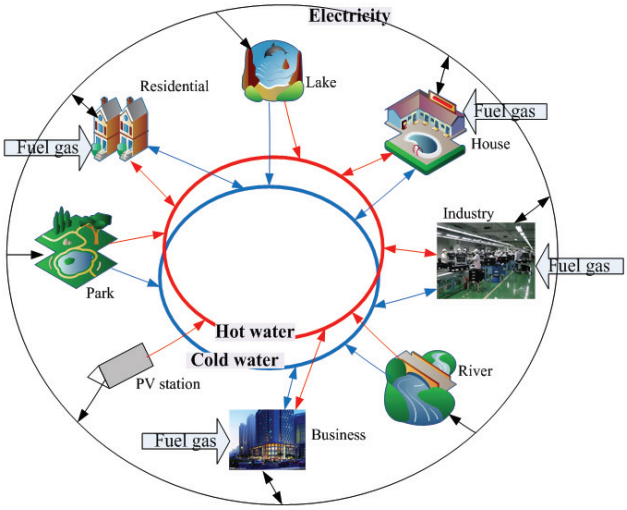

Fig. 3. CSEM diagrammatic drawing

2.2 CSEM and TPEM Comparison

The comparisons of CSEM and TPEM are listed in Table 1.

Table 1. The Comparison of TPEM and CSEM

Energy market	TPEM	CSEM
Commodities	petroleum, coal, gas etc.	electricity, hot water, chilled water, steam
Traders	countries, huge energy company	stakeholders in a community
Exchange motive	commercial profit, energy security	decreasing total cost for whole community
Spatial scale	intercontinental, countries, cities, a long distance	neighbourhood buildings in a community, short-distance with neighbouring
Transportation	transportation by sea, land and petroleum pipeline	hot/chilled water network, power grid
Facilities construction	mining, power plant, national power grid,	secondary energy station, water chillers, medium or mini type boiler

Traditional Primary Energy Markets (TPEM) is commodity markets that deal specifically with the trade and supply of primary energy. Energy market may refer to an electricity market, oil market, coal market and natural gas market etc. Typically energy development is the result of a government creating an energy policy that encourages the development of an energy industry in a competitive manner. Until the 1970s when energy markets underwent dramatic changes, they were characterized by monopoly-based organizational structures [7].

From Table 1 we can conclude that CSEM is very different with TPEM. So the current policy and research experience about TPEM can't be used for CSEM directly.

3. Challenges to build CSEM

3.1. Technical obstacles

Recent studies have investigated the feasibility of a community energy system in terms of implementing a sustainable energy system based on renewable energy and including substantial reductions in the space heating demand [8,9]. The studies conclude that energy conversion technologies must be further developed to decrease grid losses, exploit synergies, and thereby increase the efficiencies of low-temperature production units in the system.

Renewable energy, together with energy conservation and CHP production, is an essential factor in the climate change response in Europe as well as in many other regions [10].

In order to improving total community energy system efficiency, such technical problems need to be addressed appropriately:

1) Community energy system simulation models for community energy system planning, designing and operating. To build integrated community energy system, which with multi-consumers and multi-producers, needs to do a lot of work from community land-use planning stage to energy system operating stage.

2) Ingenious system design to cope with increasing uncertainties. Numerous construction projects can't be finished simultaneously, which means secondary energy producers and consumers may be changing over time. The system designing scheme should meet this challenge and to ensure system efficiency at a high level at all time period.

3.2. Financial risks

Secondary energy demand, distribution and production cost change over time, it's a hard work for managers making of operation plan. The system operating plan should meet with all consumers' secondary energy commodity demand, at the same time, to ensure that producers' supply secondary energy commodity with a low production cost. When this complicated price system associate with a dubious community secondary energy system, the failure of this price system is very common.

3.3. Who can be the organizer?

To build integrated community energy system need to do a lot of work from community land-use planning stage to system plant operating stage. Construction and management of CSEM can be taken on by a company or municipal government. This organizer should have the ability to ensure suitable planning, cost and motivation structures in relation to the operation as well as to strategic investments related to the transformation into future sustainable community energy systems. Neither company nor government can finish all of the work effortless.

In "Supporting Community Investment in Commercial Renewable Energy Schemes Final Report" [11]. They indicated that community investment in commercial energy projects has the potential for far-reaching and positive impacts. Theirs research report indicated that there is much interest in, and enthusiasm for, increasing community investment in commercial energy projects in Scotland. So the inhabitant in a community pleased to have investment in secondary energy producing and trading.

It risks encouraging governments to sit back and let others do the work that they find too difficult themselves. That is both a dangerous abdication of responsibility and a missed opportunity. Consider of community energy system design and management is a hard work for ordinary residents. A community energy system technical service department is necessary for CSEM being able to function well and properly.

Generally, the organizer of CSEM should include local government, technical service department and residents all three together. For technical and finance issues need three parts conducted consultations, which is helpful for relevant sides enhancing mutual understanding and accomplishing multiple goals.

4. Policy response: with the aid of urban detailed plan

Typically, the existing TPEM is characterized by single-purpose companies, i.e. enterprises earning profits from the sale of energy commodity as their only purpose. For CSEM, in order to reduce carbon emission, more local renewable and sustainable energy should be considered. Government should as a participant for a CSEM establishment, which can ensure the implementation of renewable and sustainable energy policy.

Urban planning is a mature system to guide land use. It is also enforceable to guide urban construction and development to some extent. Urban planning result is always regarded as the basis of government policy about the way cities looks and grows [12]. On urban detailed plan stage, the quantitative indexes of land use (such as building density/color/height, green areas coverage rate, urban road density, etc.) have been explicitly listed in the planning

results based on National or Local Standard. Based on community detailed planning results, the climate and environmental parameter, locally available energy resource (contains renewable and fossil energy resource), energy-consuming characteristics and project implementation scheduling are all explicit. Arising more accurate and suitable energy-related indicators for the community at Community Regulatory Plan stage is valuable and possible. Based on energy-related indicators of every land parcel in a community, a quantitative analysis of specific community energy system based on the detailed planning program of this community is necessary. Integrated strategic community energy infrastructure planning procedures, the planning process needs to enable integrated resource planning and community energy system planning. Because of these energy-related indicators in Community Regulatory Plan documents, Community Secondary Energy Company have to make great efforts use local renewable and sustainable energy resource, which help to reduce community energy system carbon emission. Of course, government should have tax breaks and financial support for Community Secondary Energy Companies.

The main work of community energy planning at urban detailed planning stage is to collect and analyses basic data and build regulation index system, and then find an effective approach to achieve energy saving goals. Technical models for community energy system plan and energy-related indicators confirmation have been introduced by Huang Z et al in reference [13,14]. Community energy system planning and designing results can give the results as Fig.4 present.

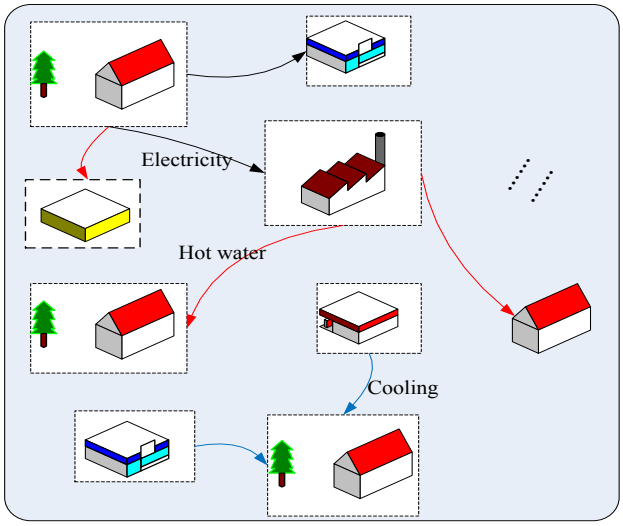

Fig. 4. A community energy system structure optimization results

5. Conclusions

At CSEM, we suppose each consumers/producers is a community secondary energy company. These Community Secondary Energy Companies purchase or sell secondary energy commodity to neighborhood proprietors. One proprietor maybe is an electricity seller in the morning but an electricity purchaser at night. Each kind of SEC production cost and marginal value at different hours within one day probably different, so dynamic pricing strategy can be utilized to cope with time-varying market. Government regulates and controls CSEM from formulating a Community Energy Plan (CEP) document and tax preferential policy and financial support policy.

Of course, this paper is just a rough approximation of CSEM, more research should devote to CSEM research.

References

[1] Malmo Municipality Skane Energy Agency. Energy Planning Guidance An Introduction. Available on http://www.energy.ca.gov/energy_aware_guide/P700-96-006.PDF.

[2] S. Eonva, Municipal energy and climate planning– a guide to the process. Available on http://www.managenergy.net/download/Norwegian_Guidebook_for_Municipalities.pdf
[3] H. Lund, S. Werner, R. Wiltshire, S. Svendsen, J. E. Thorsen, F. Hvelplund, B.V. Mathiesen, 4th Generation District Heating (4GDH) Integrating smart thermal grids into future sustainable energy systems. Energy, 68(2014)1-11, April .
[4] D. Schneider, N. Dui, I. Bogdan, Mapping the potential for decentralized energy generation based on renewable energy sources in the Republic of Croatia. Energy. 32(2007) 1731-1744.
[5] H. Lund. Renewable Energy Systems - The Choice and Modeling of 100% Renewable Solutions. Academic Press; 2009. ISBN : 9780123750280.
[6] Z. Huang, H. Yu, Approach for integrated optimization of community heating system at urban detailed planning stage. Energy and Buildings. 77(2014) 103-11.
[7] A. Konoplyanik (2004). "International Energy Markets". In Barton, Barry. Energy Security: Managing Risk in a Dynamic Legal and Regulatory Environment. Oxford University Press. p. 49. ISBN 0199271615. Retrieved 27 June 2013.
[8] B. Möller, H. Lund, Conversion of individual natural gas to district heating: geographical studies of supply costs and consequences for the Danish energy system. Appl Energy. 87(2010)1846-1857.
[9] H. Lund, F. Hvelplund, I. Kass, E. Dukalskis, D. Blumberga, District heating and market economy in Latvia. Energy. 24(1999)549-559.
[10] O. Eriksson, G. Finnveden, T. Ekvall, A. Björklund, Life cycle assessment of fuels for district heating: a comparison of waste incineration, biomass- and natural gas combustion. Energy Policy.35(2007)1346-1362.
[11] C. Haggett, M. Aitken, D. Rudolph, B. Veelen, J. Harnmeijer, S. Consulting, J. Hutton, Supporting Community Investment in Commercial Renewable Energy Schemes Final Report, Available on http://www.climatexchange.org.uk/files/5714/2132/9274/Supporting_Community_Investment_in_Commerical_Energy_Schemes_-_Dec_14.pdf
[12] R. Marlena, District Energy within the Planning Context: Exploring the Barriers and Opportunities for District Energy and Community Energy Solutions in Ontario, Pd.D Dissertations. Ryerson University, Toronto, Canada; 2013.
[13] Z. Huang, H. Yu, Z. Peng, M. Zhao, Method and tools for community energy planning, a review, Renewable and sustainable energy reviews. 42(2015)1335-1348.
[14] Z. Huang, H. Yu, Z. Peng, Approach to promote the implementation of community energy planning and the operating method, Journal of HVAC（in Chinese）44(2014)16-20.